Manitoba
Agriculture

Direct-Cut Grain Harvesting and Drying

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Harvesting Alternatives

For many years, harvesting of grains and oilseeds in western Canada has consisted of windrowing the crops at or slightly before full maturity, later picking them up with a pickup header on a combine. This method is not used in any other major grain growing area in the world. The extra labor, the high cost of windrowing and the grain deterioration that occurs in windrows during wet harvest seasons has prompted many prairie farmers to consider the alternative of direct-cut harvesting. Many who have made the change have become enthusiastic proponents of direct cutting. Direct-cut harvesting research is still quite limited on the prairies, but from the information available, there appear to be substantial benefits. The general availability of grain drying equipment has made direct-cutting a practical and economical alternative on many farms. In order to gain the maximum benefit, it is important to select shatter-resistant crop varieties and to start the harvest as soon as the cereal grain moisture content (m.c.) drops below 20 per cent. Oilseed harvesting should begin at about 14 per cent m.c.

Some of the most important considerations regarding direct cut harvesting include shattering, weather and mechanical losses; effect of MOG (material other than grain - mainly straw and chaff) on harvesting rates; and cost of direct cutting vs windrowing.

Shattering, Weathering and Mechanical Losses

Research information on grain shattering and harvesting losses is very limited for Canadian prairie conditions. The following information is based on test reports from several Agriculture Canada research stations in Saskatchewan and Alberta. Some of the varieties used in these tests are not used or recommended in Manitoba, and are mentioned only for purposes of identification.

Tests at the Agriculture Canada Research Station at Swift Current on shattering losses in wheat, oats and barley showed a substantial difference between varieties. Neepawa and Wakooma wheat were the least susceptible to shattering losses in the one month period after the grain moisture content reached 14.5 per cent. Sinton was the most susceptible, with losses that were twice as high as Neepawa. Among the wheat varieties recommended for Manitoba, Neepawa has excellent resistance to shattering, and Benito, Columbus, Katepwa, Kenyon and Roblin have good resistance to shattering.

Bonanza barley had shattering losses 1.7 times as high as Galt barley during the one month period after reaching 14.5 per cent m.c. Random oats had shattering losses three to four times as high as Kelsey oats.

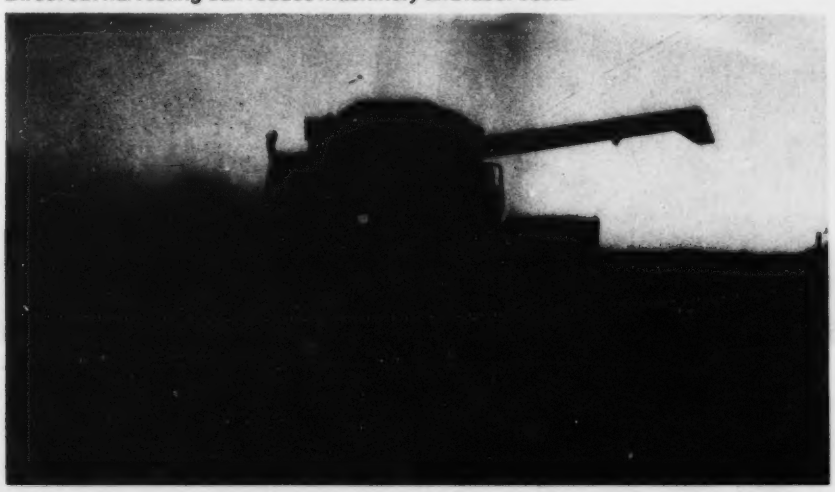
Losses varied considerably from one year to another - depending on growing conditions and weather variations following grain maturity. In the two weeks after the cereal grains reached 14.5 per cent m.c., shattering losses varied from less than 0.5 per cent up to three per cent for the more resistant varieties. Larger kernels were more likely to shatter than small kernels, thus losses were greater in years when moisture conditions were favorable.

Windrowing of wheat and barley should start at about 35 per cent m.c. Drying rates are often very rapid at the time of windrowing so the moisture content quickly drops below 30 per cent. This results in an increase in the shattering losses before cutting, and greater mechanical losses during windrowing.

Here is a comparison of the losses observed for direct cut and windrowing systems when wheat was combined at moisture contents below 14 per cent.

- If the wheat variety was susceptible to shattering and was windrowed at 30-40 per cent moisture, the losses were less for the windrow system than for direct-cut.

Direct cut harvesting can reduce machinery and labor costs.



- If the wheat variety was resistant to shattering and was windrowed at 30-40 per cent moisture, the losses were equal for both systems.
- If the wheat variety was susceptible to shattering and was windrowed at 20-30 per cent moisture, the losses were equal for both systems.
- If the wheat variety was resistant to shattering and was windrowed at 20-30 per cent moisture, the losses were less for the direct cut-system than for windrowing.

If combining was done at moisture contents of 15-20 per cent, the losses for direct cut harvesting were reduced compared to combining at 15 per cent or lower.

If harvesting was done at recommended moisture contents (windrowing at 30-40 per cent moisture, and combining at 15-20 per cent moisture) the difference in losses for all varieties averaged 0.3 per cent higher for the direct cut system with wheat crops of average yield or above. If the crops were short, the losses were higher for the windrowing system than for direct cut, because of increased pickup losses.

If weather conditions are damp during harvest, grain quality suffers less in a standing crop than in windrows because cut grain remains wet for a longer time. Also, because standing crops dry more quickly following a rain, harvesting can resume earlier.

One reason often given for windrowing is to speed drying and allow earlier harvesting. In tests at the Melfort, Lacombe and Swift Current research stations, it was found that in 28 of the 32 test years, windrowed wheat dried to 14.5 per cent m.c. from 0 to 2 days faster than standing wheat. In the other four years, it took from one day less to six days longer for the standing wheat to dry. If any type of grain drying system is available, differences in drying rates between windrowing and direct combining are of little or no practical significance. Even without drying equipment, the day or two earlier start in harvesting will seldom be sufficient to pay for the cost of windrowing. If the crop maturity is **very uneven**, windrowing hastens drying time by as much as a week.

Green kernels caused by uneven germination are often a concern during harvest. Tests at the Swift Current research station indicate that levels of green wheat kernels declined at a similar rate in standing and windrowed crops. The rate varied from year to year depending on moisture and temperature conditions. It was also found that Neepawa and HY320 wheat could be harvested and dried at moisture contents as high as 28 per cent without loss of grade - if the maturity was reasonably uniform. Tests by PAMI indicate that if wheat or barley are combined at moisture contents below 25 per cent and then dried, very few green kernels remain, and there is no weight loss. However, to reduce chances of downgrading due to green kernels, and to improve test weight and germination, grain moisture should be allowed to drop below 20 per cent m.c. before harvesting.

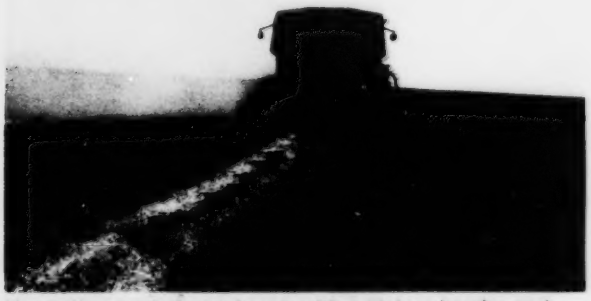
Effect of MOG on Harvesting Rates

The amount of MOG (material other than grain, mostly straw and chaff) that is fed into a combine significantly affects the capacity of the combine. The ratio of straw to grain is usually referred to as the MOG/G ratio. A high MOG/G ratio means that there is considerable straw and chaff compared to the amount of grain. Figure 1 is part of a series of PAMI tests on Neepawa wheat and Bonanza barley, showing the change in harvesting rates with varying ratios of straw to grain.

The less straw fed into the combine, the more grain could be harvested in a given time. This effect was more pronounced in wheat than in barley. The main limiting factor in combine capacity with high MOG/G ratios was the ability of the straw walkers to separate the grain from the straw. With wheat, there was also a significant increase in unthreshed grain as the amount of straw increased.

The amount of straw processed by the combine remained fairly constant, regardless of how much grain accompanied the straw. In other words, when harvesting wheat, if the length of the straw fed into a combine was increased from one to 1.5, there was a reduction from one to 0.67 in the combine's grain harvesting capacity. When harvesting barley, an increase in straw from one to 1.5 resulted in a decrease from one to 0.87, in the grain harvesting capacity of the combine.

Windrowing crops requires extra equipment and labor.

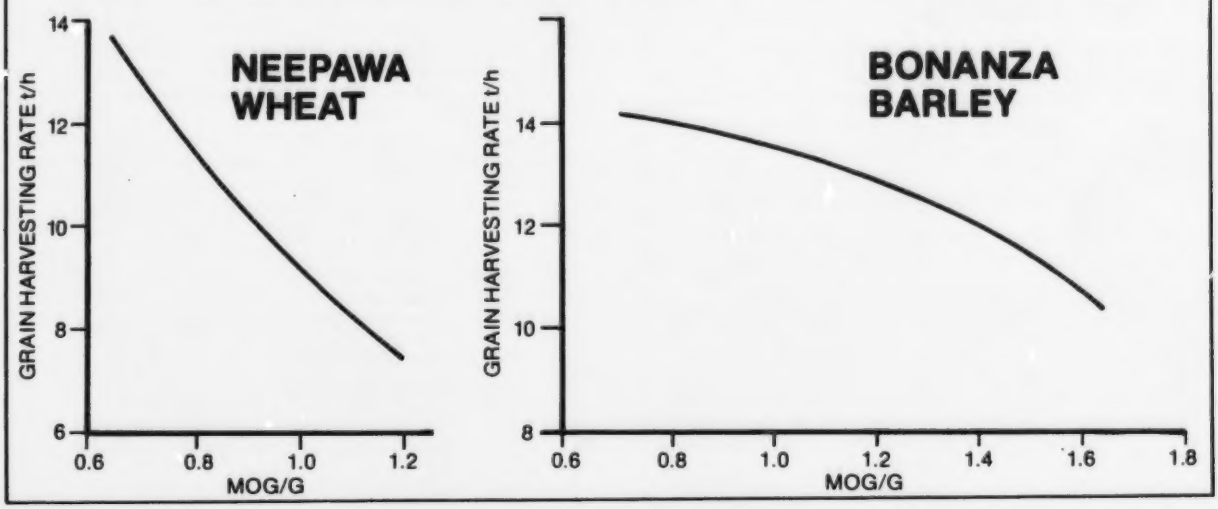


Harvesting a windrowed crop with a pickup header and combine.

In order to obtain maximum harvesting capacity from a combine, it is necessary to minimize the amount of straw being processed. Field observations indicate that where the crop is standing reasonably well, the reduced straw throughput with direct cutting results in a harvesting rate about 20 per cent faster than when picking up windrows. If the crop is bent over or lodged, the cutting height may need to be the same as when windrowing. Under these conditions, the harvesting rates would be about equal. If the straw is not fully mature at the time of combining, it takes more power to put through, thus limiting the harvest rate. Thus, under suitable conditions, harvesting rates may be substantially faster with direct cutting; in other situations, it is approximately equal to picking up windrows. Using the same MOG feed rate, tests conducted by PAMI showed a three per cent loss when picking up from windrows, compared to a two per cent loss from direct-cutting. The reduced losses are probably due to more uniform feeding into the combine.

A new type of header, called a stripper, has been developed by the National Institute of Agricultural Engineering in England. It strips the heads or pods off the straw, and therefore reduces the amount of straw entering the combine to about 10 per cent of normal in cereal crops. In lodged or overripe crops, the straw amounts are reduced by about 50 per cent. The grain harvesting rates are normally increased by 30 per cent, to 50 per cent, as compared to using a

FIGURE 1 — **CHANGE IN HARVESTING RATES WITH VARYING RATIOS OF STRAW TO GRAIN**



A newly-developed stripper header reduces straw throughput.

conventional direct cut header. Some tests have shown header losses to be equal or lower with the stripper in cereals and flax, while other tests show losses to be twice as high as for a conventional header. **The stripper is not recommended for canola.** A limited number of commercial production units were sold in the 1988 harvest season.

The development of relatively short-strawed crop varieties would be advantageous for direct-cut harvesting. This would allow faster harvesting by reducing the straw throughput. Direct-cutting long strawed varieties, leaving a high stubble, may require an additional tillage operation for seedbed preparation. This cost should be offset by the faster harvesting rates and reduced grain losses from the combine.

Costs of Direct Cutting vs Windrowing

When changing harvesting systems, the cost of the direct cut header is a major consideration.

TABLE 1 — **AVERAGE COSTS FOR VARIOUS WIDTH DIRECT-CUT HEADERS**

Width	Capital Cost $	Annual Cost $
6.1 m (20 ft.)	10,200	1500 - 1800
7.3 m (24 ft.)	11,300	1700 - 2000
9.1 m (30 ft.)	13,400	2000 - 2400

The annual cost for interest, depreciation, repairs and maintenance is typically about 15-18 per cent of the capital cost. In a harvest season of 100-125 hours, one could expect to harvest about 65 hectares (a quarter section) for each metre width of header. This would result in a cost of about $4/ha ($1.60/acre) for the header.

An average header, with pickup, costs about $8200, for an annual cost of $1200-1500. This is between $300 and $900 per year less than a direct-cut header, depending on its size.

The cost of windrowing with a self propelled machine is about $11-12/ha ($4.50-$4.90/acre) including labor. With a pull-type machine, the cost is about $6-$7/ha ($2.80/acre). The operating costs (repairs, labor and fuel) amount to $4-$5/ha ($1.60-$2/acre).

Because grain dries faster (after rain or dew) when it is standing than if it is in a windrow, there are more hours in a season available for combining with direct-cut. This allows the farmer to harvest the same area with a smaller combine, or a larger area with the same combine. Increasing the total area harvested by 10 per cent would result in a decrease of about seven per cent in the combining cost per hour. This represents a saving of approximately $2.50-$3/ha ($1-$1.20 acre).

Table 2 shows a comparison of costs between windrowing and direct cutting 500 hectares (1240 acres) of wheat.

If the farmer already owns a windrower and pickup header, he/she may wish to know whether it is more economical to use the equipment he/she already owns or switch over to direct-cut. In this case, he/she would consider only the operating costs (fuel, labor and repairs) for the windrower and pickup header. This amounts to $2350 - $2850 in the example in table 2. Harvesting costs with the windrower-pickup system would therefore be as high or higher than if he/she purchased a direct-cut header.

Where a farmer grows some crops that he/she does not wish to direct-cut, he will also need to have access to windrower and pickup header for a portion of the harvest. He/she may be able to rent a windrower from a neighbor and have these crops custom combined, or because of the lower use, buy a used or pull-type windrower instead of a new or SP model. In any case, the lower use will reduce the depreciation and repair costs of the windrower. Following the previous example and assuming that 25 per cent of the crop would be windrowed, the costs would be as follows.

TABLE 3 — **COSTS OF HARVESTING WITH BOTH SYSTEMS**

Headers — direct cut	$1900
— pickup	$1150
Windrowing	$1250* or $2000**
Extra pre-harvest losses ..	$ 300
Extra combine operating costs	$ 300
TOTAL	$4900* or $5650**

**custom windrowing 125 ha @ $10/ha ($4/acre)*
***owning a PT windrower*

In these examples, the total harvesting cost when using a windrower and pickup for 25 per cent of the crop and direct cutting the rest is equal to (or less than) the cost of harvesting the entire crop with the windrower pickup system. Each farm should be assessed individually to determine the relative economics of the direct-cut system vs the windrow pickup system vs a combination of the two.

Because of limited labor availability on most farms, it is often not possible to windrow and combine at the same time. The farmer may be windrowing some of the time when he/she should be combining, or else have to windrow some of the crop when it is over mature. The result of either choice is extra costs due to grain weathering and higher harvesting losses.

TABLE 2 — **COMPARISON OF COST BETWEEN WINDROWING AND DIRECT-CUTTING**

Annual Costs	Direct Cut	Windrow & Pickup
Header	$2000	$1400
Windrowing	—	$3000 - 6000
Extra pre-harvest losses (0.3% x 2.5 t/ha x $150/t x 500 ha)	$560	—
Extra combine operating cost ($2.50/ha x 500 ha)	—	$1250
TOTAL	$2560	$5750 - 8750

Other Considerations of Direct-Cutting vs Windrowing

- Direct-cut normally requires the use of a self-propelled combine due to limited header widths available for pull-type combines.
- Direct-cut requires the availability of grain drying equipment (either heated or unheated air) so that harvesting can begin earlier to minimize shattering losses. Extra costs for drying have not been attributed to direct-cutting in the comparison above, since drying is also recommended for windrowed crops. If field drying is chosen, the costs are also very similar (see Grain Drying section).
- Comparative harvesting losses for harvesting canola by direct-cut have not yet been determined in western Canada, although in Europe direct harvesting of canola is standard practice.
- Some special crops need to be harvested with direct-cut headers so having one available expands the farmer's cropping options.
- With direct-cut, combining can start earlier in the day and sooner after a rain, but may need to stop earlier in the evening due to higher humidity. In total it appears that more hours per season are available for direct-cut combining than for picking up windrows.
- Combine operation tends to be smoother with direct cut, with less surging and plugging. This reduces losses for direct cut, even with the same straw throughput.
- Elimination of windrowing substantially reduces labor.
- There is less grain deterioration and grade loss, and less chance of grain sprouting in wet weather with standing grain.
- There is reduced likelihood of bird damage with standing grain.
- If a severe wind or hail storm hits a standing crop the losses may be greater than in a windrowed crop.
- Direct-cutting of flax is preferable to windrowing and picking up; it eliminates one operation, plus the possibility of windrows being blown around by strong winds.
- If low spots in the field are later maturing, they can be left for later harvesting when direct-cutting. This reduces chances of lowering the grade and yield.
- When direct-cutting, wet spots in the field can be left to dry with less inconvenience to the harvesting operation.
- If the crop is very thin or short, windrowing and picking up can produce excessive harvesting losses.

Grain Drying

A grain dryer as part of the harvesting system gives the farmer several important advantages:

- Harvesting can begin earlier in the season, which reduces grain weathering and/or shattering losses.
- Harvesting can proceed during periods of damp weather, and for longer periods during the day, again reducing weathering losses.
- A smaller combine can be used because there are more hours available to complete the harvest.
- The moisture content of the grain can be more accurately controlled, thus minimizing overdrying losses (e.g.; if grain is harvested at 12 per cent m.c. instead of 14.5 per cent, there is a net weight loss of three per cent).
- Earlier completion of harvesting enables more fall weed control measures to be taken.
- Elimination of spoilage in stored grain as a result of tough or damp seed.
- Provides the option of direct-cut harvesting of many crops, providing savings in machinery and labor costs.

The disadvantages of grain dryers are also noteworthy:

- The capital cost, of the dryer and any associated equipment should be considered.
- The labor required to operate or supervise the drying operation is another consideration. This factor is insignificant with unheated air grain dryers, and has been greatly reduced by automatic controls and better monitors on heated air grain dryers.
- The operating costs are significant (electrical for unheated air and primarily fuel costs for heated air dryers).

The selection, operation and monitoring of grain dryers is discussed in detail in two Manitoba Agriculture publications: 'Heated Air Grain Dryers' and 'Grain Aeration and Unheated Air Drying'. Additional assistance on these topics is available from agricultural engineers with Manitoba Agriculture throughout the province, as well as from the "Grain Drying" computer program from Manitoba Agriculture. If any comparisons of different drying systems are desired, it is highly recommended that this computer program be used. Many different options can be considered without tedious manual calculations.

Effect of Grain Moisture Content on Harvesting Rates and Losses

Farmers who are familiar only with harvesting dry grain are often apprehensive about combining it damp. Modern combines will harvest grains at moisture contents of 30 per cent or higher without difficulty. The reduction in straw breakup and dust actually makes higher moisture grain harvesting more pleasant for the operator. **The harvesting capacity of a combine is either maintained or improved when harvesting high moisture grain as shown below.**

In a series of tests conducted by PAMI with Neepawa wheat at four different moisture contents, the following harvesting rates were obtained for the same rate of grain loss:

Grain moisture content %	Harvesting rate %
23.0	100
19.3	118
14.4	100
11.0	89

Another series of tests on Bonanza barley showed the following rates for the same grain loss rate:

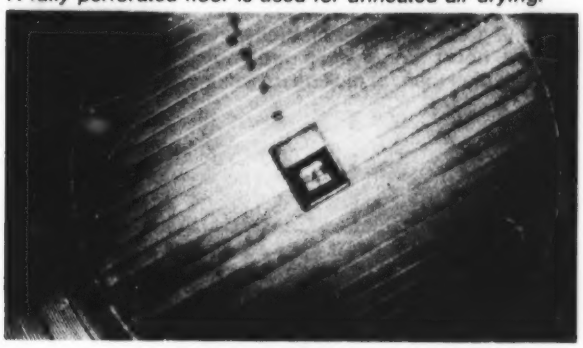
Grain moisture content %	Harvesting rate %
32.8	100
19.4	105
14.9	106

There is little, if any, difference in grain damage when wheat or barley is harvested at different moisture contents. Combine adjustments can usually compensate for moisture variations. In very dry conditions it is more difficult to control grain cracking. Summing up, **combine capacity and performance is as good or better in tough or damp conditions as compared to dry grain.**

Unheated Air Grain Drying Costs

Unheated air drying with an electric fan.

A fully perforated floor is used for unheated air drying.



An unheated air drying system typically consists of a fan, transition and perforated floor installed in a steel bin. In some cases, roof vents and/or spreaders may also be used. The cost of equipment varies according to the size of the bin and fan, and there is also a substantial variation from one supplier to another. One of the most frequent mistakes made in equipment selection is to get an inadequate air distribution system for the fan size selected. An agricultural engineer should be consulted to ensure that proposed equipment is properly matched and is suitable for the intended use.

A typical cost of installing a fan, transition, and fully perforated floor in a 5.8 m (19 ft.) diameter bin is about $2500-$3000 depending on fan size. This would be adequate to dry 125 tonnes (4600 bus.) of wheat or 100 tonnes (4600 bus.) of barley from 19 per cent m.c., or 80 tonnes (3500 bus.) of canola from 13 per cent m.c. Some typical annual costs for early September harvest are shown in Table 4.

TABLE 4 — **COSTS OF UNHEATED AIR DRYING**

Cost	Wheat 125 t Barley 100 t	Canola 80 t
Ownership (interest, depreciation and repairs)	$350 - $400	$400
Labour (monitoring)	50 - 100	50
Electrical power	250 - 350	150 - 250
Overdrying*	75 - 150	300 - 450
Total annual cost	$725 - $1000	$900 - $1150

**Overdrying means reducing the moisture content of the grain to less than the maximum allowed for "dry" grade. When grain is dried in a bin, by the time the grain at the top surface is dry, the grain underneath is normally below the maximum moisture content. For each one per cent below the maximum moisture content there is a weight loss of 1.2 per cent which results in a 1.2 per cent loss in sale value. For wheat the maximum "dry" m.c. is 14.5 per cent, for barley it is 14.8 per cent and for canola it is 10 per cent. The assumed wheat price is $150 per tonne and the canola price is $350 per tonne.*

This amounts to about $6 to $9 per tonne ($.15-$.22/bus.) for wheat and barley, or $11-$14 per tonne ($.25-$.32/bus.) for canola. The overdrying cost is $.75-$1.50 per tonne ($.015-$.03/bus.) for wheat and barley, and $3.75-$5.50 per tonne ($.08-$.12/bus.) for canola. Higher crop prices will increase overdrying costs proportionally. In years with warm, dry fall weather, the over-drying costs will also be greater. Some years, the electrical power usage would be much lower — perhaps only $1 per tonne ($.02-$.03/bus.) and some years it could be as high as $4-6 per tonne ($.09-$.16/bus.) depending on seasonal temperatures and relative humidities.

These costs are based on typical 1988 values. Different bin sizes, crop prices, interest rates, etc. will produce different results. In evaluating your own situation, you should use values that are relevant to your farm. The computer program "Grain Drying" referred to earlier (available at offices of Manitoba Agriculture) allows you to choose any input values you desire, thereby providing you with an accurate cost analysis for any situation.

Adding Heat

Farmers are often tempted to add "a little heat" to speed up the drying process. In most situations this is the wrong thing to do. Adding even as little as 5° C can result in severe overdrying in the bottom layers, and can actually increase the dangers of spoilage at the top of the grain pile if there is insufficient airflow. The initial cost of the heater, the fuel, and the overdrying can be substantial as shown in Table 5. The cost of a heater of five to 15 kW is between $600 and $1000, which results in an annual investment cost of about $100 to $150.

In this example, using a heater resulted in an additional cost of about $700. This amounts to about $5.75 per tonne ($.16/bus).

One of the very few situations where adding heat may be beneficial is when the grain is still damp after mid-October and it is apparent that it will not dry without added heat. The higher drying cost may be justifiable in this situation. If heat is added, these guidelines should be followed:

- don't add more than 5° C;
- be sure that the airflow rate is at least 10 L/s/m³ (litres of air per second per cubic metre of grain);
- shut off the heater whenever the relative humidity drops below 80 per cent or the ambient temperature exceeds 15° C;
- stop drying when the average grain moisture content is "dry" and mix the grain. This requires considerable sampling to determine a true average for the whole bin. On most farms adequate mixing is very difficult to accomplish;
- run the fan for at least one day after the heater is shut off.

Since cereal grains can be stored safely over winter at moisture contents up to 20 per cent, and oilseeds up to 14 per cent, it is often better to keep the crop cold over winter and finish drying it in the spring rather than spending the extra money to dry it in the fall with added heat. (Frequent checking of bins is necessary.)

TABLE 5 — **COSTS OF ADDING HEAT** - *Wheat harvested at 18%, Sept. 1, 125 tonnes (4600 bus)*

Cost	No Added Heat	5° C added heat
Fan operating	$250	$140
Heater operating	—	235
Overdrying	115*	585*
Heater investment	—	125
	$365	$1085

**If proper mixing of the grain was possible, the overdrying cost could be reduced or eliminated.*

Heated Air Grain Drying Costs

A heated air grain drying system typically consists of a wet surge bin, a dryer, a dry surge bin and automatically controlled augers to fill and empty the dryer. Many farms already have hopper bottom bins that can be used for surge bins. If at all possible, the grain should be transferred directly into aerated storage from the dryer or the dry grain surge bin so that grain handling is kept to a minimum.

Basic heated air dryers start at $15,000, and the capital investment accounts for a major portion of the total drying costs especially when the dryer is used for 100 hours per year or less. If the dryer is to be used only for a week or two per year, it is important to minimize the capital investment, either by buying a smaller or used dryer.

Table 6 shows some typical costs for heated air drying with a batch dryer system costing $26,000.

Propane costs in Table 7 are based on an ambient temperature of 15° C. If the outdoor temperature is 0° C, the propane costs would be 30 per cent higher (about $.60/tonne or $.015/bus.). If the canola can be sold as "dry" at 10 per cent m.c. there is a significant benefit to the farmer. Not only would the $4.25 per tonne ($.09/bus.) overdrying cost (due to extra weight loss) be eliminated, but the fuel, labour and repair costs would also be reduced by $.75 per tonne. This creates a total benefit of $5 per tonne for drying to 10 per cent rather than nine per cent.

The "Grain Drying" computer program referred to earlier can be used to determine costs of heated air drying of various crops with any combinations of investment and operating conditions, moisture contents and air temperatures.

Heated air grain dryers should be set up to transfer dried grain directly into storage.

Grain dryers can be used to reduce field losses and extend the harvesting season.

TABLE 6 — **TYPICAL COSTS FOR HEATED AIR DRYING WITH A BATCH DRYER**

	$/tonne ($/bus.)	
Tonnes per year	**Wheat (18 to 14% m.c.)**	**Canola (13 to 9% m.c.)**
250	$19.25 ($.53)	$23.00 ($.52)
500	12.75 (.35)	16.50 (.37)
750	10.25 (.28)	14.00 (.31)
1000	9.25 (.25)	13.00 (.29)
1500	8.25 (.23)	12.00 (.27)

With an initial moisture content of 20 per cent for wheat or 15 per cent for canola, the cost per tonne is increased by $1.50 ($.04/bus.).

TABLE 7 — **COST BREAKDOWN FOR DRYING 500 TONNES PER YEAR**

	$/tonne ($/bus.)			
Annual Costs	**Wheat**		**Canola**	
Ownership (interest, depreciation and repairs)	$ 6.80	($.19)	$ 6.80	($.15)
Labour	2.00	(.05)	2.40	(.05)
Propane @ $.22/L	2.05	(.06)	1.85	(.04)
Electrical and repairs	1.00	(.03)	1.20	(.03)
Overdrying*	.90	(.03)	4.25	(.09)
TOTAL	$12.75	($.35)	$16.50	($.37)

**Based on maximum "dry" moisture content of 14.5 per cent for wheat and 10 per cent for canola, a wheat price of $150/t and a canola price of $350/t.*

Comparison of Heated and Unheated Air Drying

Using the examples for unheated and heated air drying (Tables 4 and 6), there is a cost advantage for unheated air drying of wheat, barley and canola at 1000 tonnes (40,000 bus.) per year or less. At throughputs of over 1500 tonnes (60,000 bus.) per year, the cost advantage goes to the heated air dryer. However, there are a number of other factors which must also be considered in choosing between the two systems:

- With unheated air drying, the crop may not finish drying in the fall especially if it is harvested after mid-September. This may create financial losses if marketing must be delayed until the following spring.
- If grain crops must be harvested above 20 per cent moisture, or canola above 14 per cent, unheated air drying is impractical due to excessive airflow requirements.
- Removing more than one or two points of moisture from flax is impractical with unheated air dryers, due to high airflow resistance.
- Electric power availability may limit the total fan capacity that can be used. To dry 1000 tonnes (37,000 bus.) of wheat at one time with unheated air would require an electric power input of 60 to 80 kW.
- Heated air drying requires close monitoring during the drying operation, while unheated air drying requires a few minutes of attention each day for several weeks.
- Costs of drying small amounts of grain with a heated air dryer can be reduced by purchasing a less expensive used dryer.
- An unheated air drying system can be developed over the years, one or two bins at a time, thus spreading out capital requirements.
- The capacity and fuel efficiency of a heated air dryer can be greatly improved by using the dryer only for heating. Cooling and the removal of the last few percentage points of moisture can be done more economically in a bin with a perforated floor and fan.
- Grain that has been dried in a heated air dryer should be aerated in storage to help equalize moisture variations and to provide adequate cooling for safe storage.

Field Drying

Windrowed crops may suffer serious quality losses during periods of wet weather.

With costs of grain drying generally in the range of $8 to $14 per tonne ($.22-$.38/bus.) grain drying may not appear to be economical. However, these costs must be balanced against the cost (potential loss of income) of field drying. Field drying costs are mainly weathering losses which may cause a loss of grade and weight, plus the overdrying that occurs in the field if harvesting isn't begun until the crop is dry enough to store. As an example, with wheat at $150 per tonne, the following losses may occur if the crop is left in the field until it is dry.

An average loss of one grade would represent a cost of about $17 per tonne, which is more than the cost of either heated or unheated air drying in most instances. Field drying is therefore not necessarily the lowest cost choice. The reduced personal stress and being able to finish the harvest earlier are other important benefits of having and using a grain drying system.

TABLE 8 — **POTENTIAL $ LOSSES FROM FIELD DRYING**	**$/tonne**	**($/bus.)**
Grade losses from weathering (up to 2 grades at $5 - $20/t)	0 - $25	(0 - $.68)
Weight loss from weathering, 3% per grade (up to 2 grades)	0 - $9	(0 - $.24)
Overdrying in field (starting at 14.5% m.c., finishing at 12%)	0 - $2	(0 - $.06)
TOTAL	$0 - $36	($0 - $.98)

Costs of Owning and Operating a Combine

Many options are available to a farmer for harvesting grain and oilseed crops. The farmer may purchase a new or used combine, either self-propelled or pull-type, keep it for only a few years and trade it in, or keep it until it's worn out. The farmer may also choose not to buy a combine and have crops harvested by a custom operator. One of the important factors which affects the choice to be made is the relative costs. Since a combine is one of the two most expensive machines on most farms, it is worthwhile to consider the different alternatives before making a decision.

Cost comparisons for a self-propelled (SP) and a pull-type combine, each with a separating area of 10 m^2 (15,500 $in.^2$) are shown in Table 9. A nine per cent interest rate and an 18 per cent declining balance depreciation rate were used. The costs include both fixed and operating costs, and are average hourly costs for the number of years indicated. The custom combining rate per hour is $163 for the self-propelled combine and $135 for the pull-type.

Table 9 can be used to help in selecting an economical size and age of combine. For example, if a certain size of combine would require 100 hours to complete the harvest, the farmer might select a three year old pull-type and trade it in after three years. This would result in an average hourly cost of about $138. Another choice which would result in similar total costs would be to buy a new pull-type and use it for 12 years. He/she might also consider a smaller combine which would take 150 hours to complete the harvest. With this option, the farmer would again have similar costs if he/she bought a new pull-type and used it for five years, or a three year old self-propelled which was used for six years. All of these options would have similar costs to having the crop harvested by a custom operator with a pull-type combine ($135/hour).

A comparison of costs between new and used combines can also be made from the data provided. For example, the cost of owning and operating a used combine that was purchased at 55 per cent of its original new price after three years of use, is between 65 and 75 per cent of the cost incurred with a new combine. Also, if the farmer owns a suitable tractor for use with a pull-type combine, the total combining cost is about 65-70 per cent of what it would be with the same size of self-propelled combine. This is primarily due to the initial price of a pull-type combine being about 60 per cent as much as a self-propelled of the same size. It should be noted, however, that a pull-type combine is much less suitable for direct cut harvesting due to limited header widths. If is also less convenient to operate than a SP combine. None of the above comparisons consider income tax implications. These need to be assessed individually for each farming situation.

The computer program "Combine" can be used to determine the costs of any combine ownership options, using whatever assumptions and inputs the user desires. The program can be accessed at any Manitoba Agriculture office. The factsheet "Guide for Estimating Farm Machinery Costs" can also be used to determine costs of combine ownership.

TABLE 9 — **HOURLY COSTS OF OWNING AND OPERATING COMBINES (1988)**

A. New Combine	Hours of Use per Year	Self Propelled $/hour	Pull-Type $/hour
Trade after 3 years	100	318	209
	150	226	151
	200	180	123
Trade after 6 years	100	261	173
	150	188	128
	200	152	106
Trade after 12 years	100	196	133
	150	147	103
	200	123	88
B 3 Year Old Combine			
Trade after 3 years	100	203	138
	150	150	105
	200	124	89
Trade after 6 years	100	174	119
	150	132	94
	200	111	80
Trade after 9 years	100	155	108
	150	121	87
	200	104	76
C. 6 Year Old Combine			
Trade after 6 years	100	131	93
	150	106	77
	200	94	70

Combine Adjustments

Most combine operator's manuals provide much helpful information on combine operation and adjustment. The operator should spend sufficient time studying the manual to become totally familiar with the manufacturer's recommendations before the harvest season. Additional helpful information can be obtained from PAMI combine test reports.

A quick reference list of some of the most common combining problems is given below, along with the most likely causes of these problems.

Problems and Possible Causes

1. **Grain not threshed from heads**
- cylinder or rotor speed too low
- too much clearance between cylinder and concaves
- worn cylinder bars or concave bars
- overfeeding or underfeeding
- concave filler strips or cover plates required.

2. **Cracked grain in grain tank**
- too little clearance between cylinder and concaves
- cylinder or rotor speed too fast
- too much threshed grain in tailings return
- too many concave filler strips installed.

3. **Backfeeding and slugging of cylinder**
- feed rate too high
- crop too damp or green
- cylinder speed too slow
- concave setting too close
- engine governor not working properly
- rear beater or stripper bar too far from cylinder or excessively worn
- concave grate plugged.

4. **Grain loss over straw walkers**
- straw walkers overloaded due to too high a feed rate
- excessive straw breakup due to excessive cylinder speed or concaves set too close
- concave grate plugged
- too many concave filler strips installed
- improper straw walker speed
- damaged or missing check flaps
- straw matting on walkers — add additional riser fingers or fishbacks
- check flaps too far forward causing buildup of material on front of walkers
- check flaps too far back, allowing grain to be thrown back too far
- cylinder speed too low causing insufficient separation at the concaves.

5. **Grain loss over upper sieve (chaffer)**
- too little wind (if grain is being carried out)
- wind blast not properly directed
- too much wind (if grain is being blown out)
- too much broken straw and chaff caused by excessive cylinder speed, concaves set too close, or too high a feed rate
- chaffer extension too low or closed too far
- upper sieve (chaffer) not open far enough
- too much tailings return.

6. **Foreign material in grain tank**
- lower sieve (shoe) open too far
- too little wind
- too much broken straw and chaff caused by excessive cylinder speed, concaves set too close, or too high a feed rate
- windblast not properly directed
- upper sieve (chaffer) open too far
- too much tailings return
- improper shaker speed.

7. **Too much grain in return tailings**
- lower sieve (shoe) closed too far
- overloaded sieves due to insufficient windblast
- too much broken straw and chaff caused by excessive cylinder speed, concaves set too close, or too high a feed rate
- too much wind or improperly directed wind blast
- improper shaker speed
- chaffer not open far enough

8. **Excessive return tailings**
- chaffer and chaffer extension open too far
- chaffer extension set too high
- too little wind
- too much broken straw and chaff caused by excessive cylinder speed, concaves set too close, or too high a feed rate
- windblast set too far forward
- improper shaker speed.

Crop Desiccation

In Manitoba, desiccation of certain crops, including flax and canola/rapeseed (Polish type only), is sometimes practiced to shorten the time from maturity to harvest. Desiccation chemically accelerates the drying of plants, and results in the destruction of all plant parts covered by the chemical. Green weed growth which can slow harvest operations is also killed.

In most years, natural plant maturity and fall frosts dry crops down sufficiently for harvest. However, in some years when the crops are late maturing or there is substantial second growth, desiccation may provide an alternative to windrowing. **Desiccation does not speed up the physiological maturity of a crop, and treatments should not be applied until maturity is reached.**

Flax and canola/rapeseed (Polish type only) can be desiccated with the contact herbicide Reglone.

Flax should be sprayed when 75 per cent of the bolls are mature. Do not spray when the crop is immature or if the field has been injured by frost. Combining can commence when all vegetative growth has dried down and when the flax seed reaches the desired moisture content for harvesting (usually 10.5 per cent or lower).

Canola (Polish type only) should be sprayed when the crop is 60 to 75 per cent seed turn (green to brown or yellow). Do not spray when the crop is immature or past the recommended stage of maturity. To determine crop stage, examine the seeds in the pods at three heights on the stem. The top pods should show half the seeds green, with a few early ripening seeds dark brown and yellow. In the middle pods, 90 per cent of the seeds should be reddish to dark brown and yellow. The pods from the bottom third should have all the seeds dark brown and yellow. Combining should begin when the seeds reach the desired moisture content for harvesting (usually nine per cent or lower) but no later than 14 days after treatment; pod drop and some shattering can occur in high winds with standing crop.

No products are available for desiccation of cereal crops.

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